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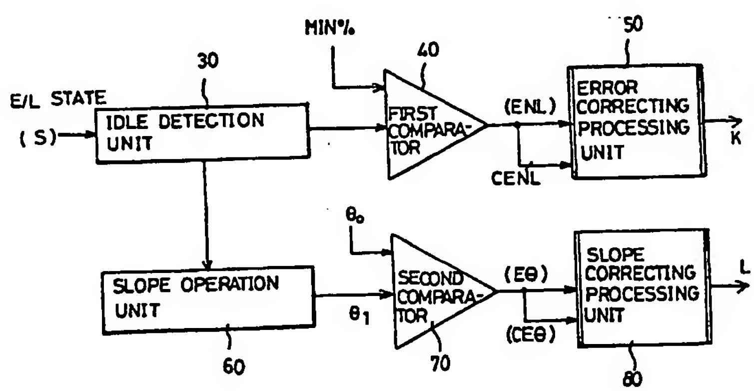
(54) Weight detecting apparatus for elevator

(57) A weight detecting apparatus for an elevator is capable of correcting an error in a signal indicative of passenger weight, occurring due to variations in characteristics of an anti-vibration rubber and a differential transformer, thereby achieving a correct weight detection. The apparatus includes a load detection data unit for outputting load detection data, a maximum/minimum value detection unit for recording a maximum value and a minimum value of the load detection data, an idle detection unit for outputting load detection data indicative of the idle state, a first comparator (40) for outputting an error (ENL) in load detection data generated at the idle state and a variation (CENL) in the error, an error correcting processing unit (50) for determining a first correction value for correcting the error and the error variation from the output signal of the first comparator, a slope operation unit (60) for providing a characteristic slope from the load detection data outputted from the load detection unit, a second comparator (70) for outputting an error (Eθ) in slope of the characteristic of the differential transformer and a variation (CEθ) in the slope error, and a slope correcting processing unit (80) for determining a second correction value for correcting the slope error and the slope error variation from the output signal of the second comparator.

FIG.4



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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FIG.1
CONVENTIONAL ART

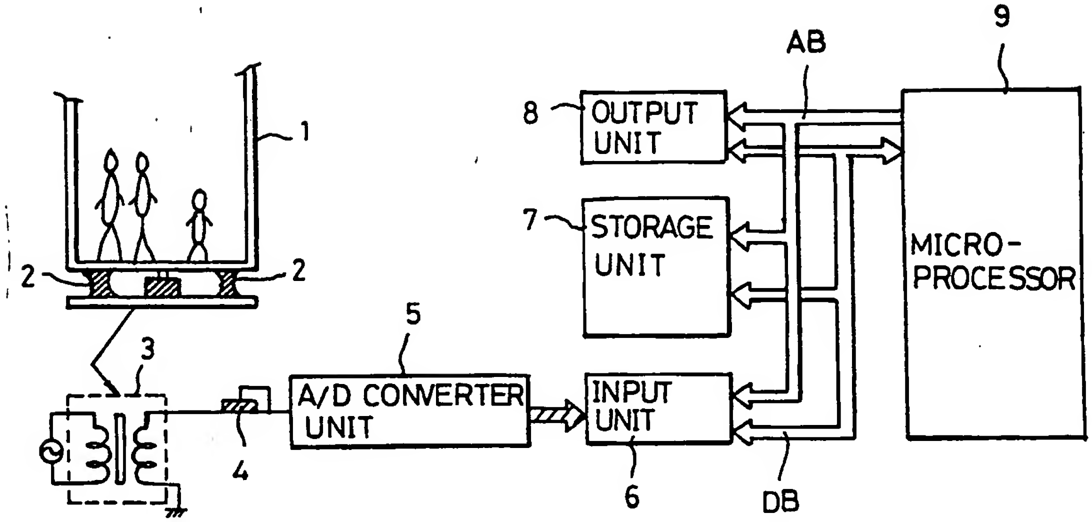


FIG.2
CONVENTIONAL ART

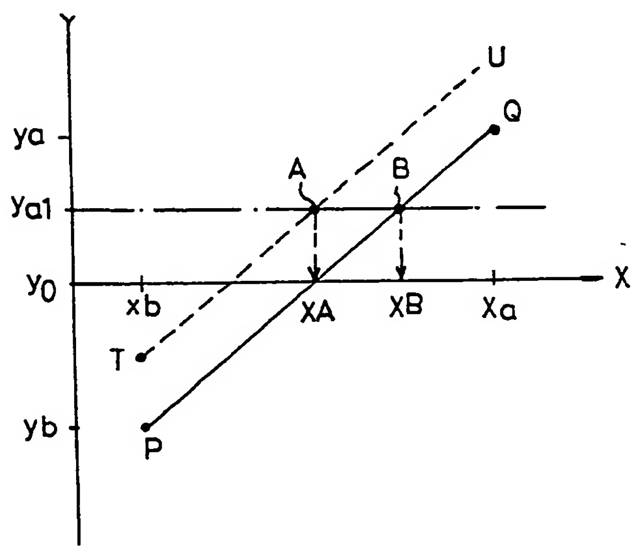


FIG.3

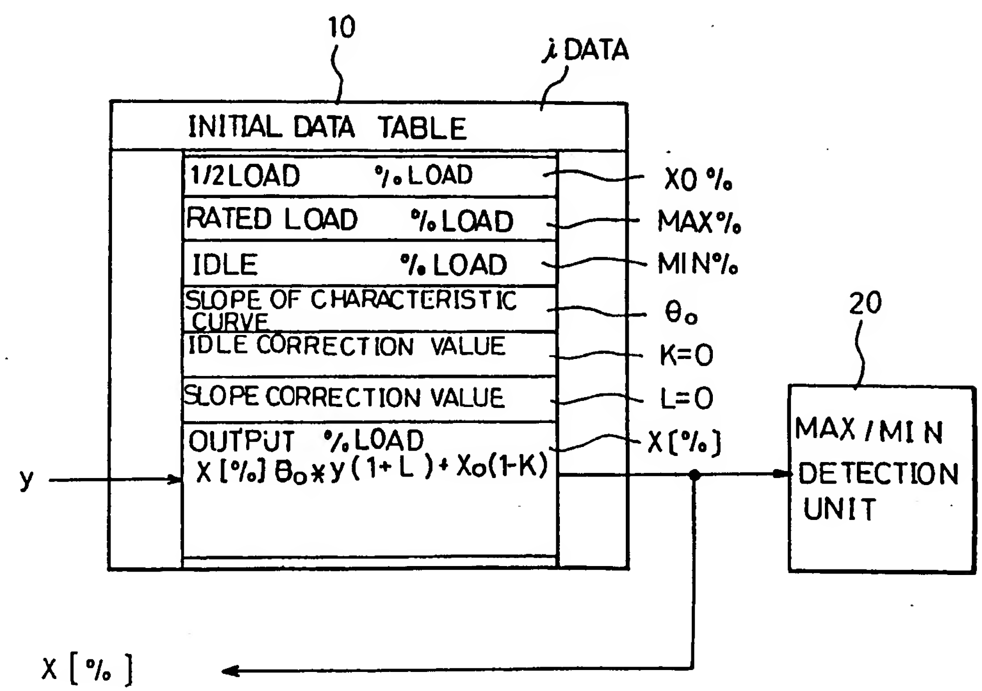
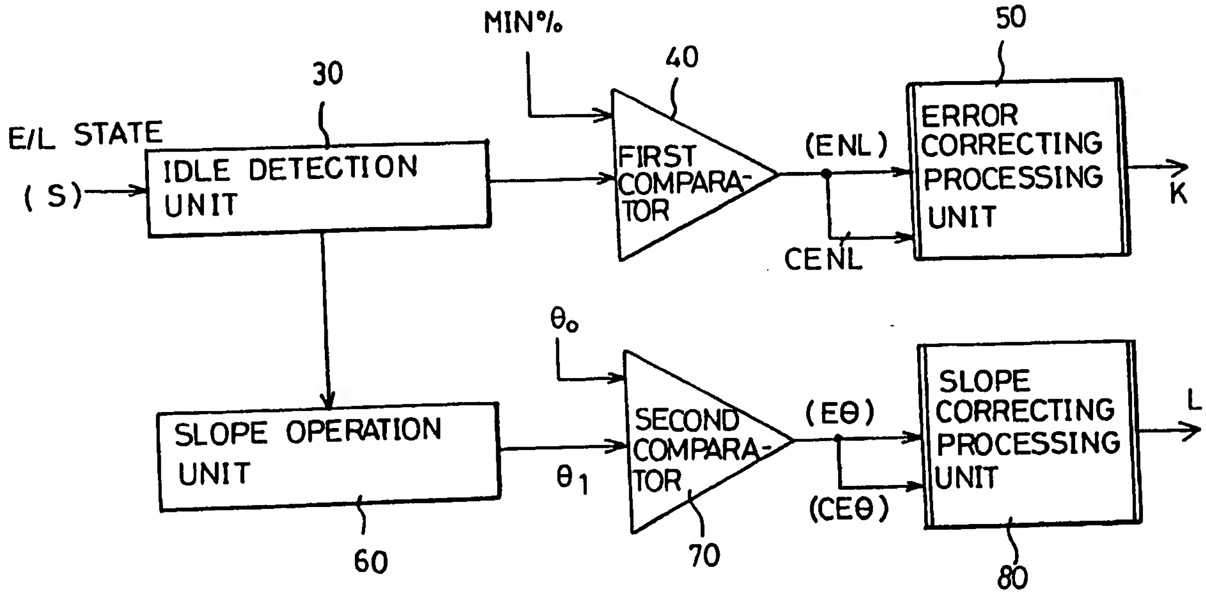

10
i DATA
INITIAL DATA TABLE
1/2LOAD %LOAD
RATED LOAD %LOAD
IDLE %LOAD
SLOPE OF CHARACTERISTIC CURVE
IDLE CORRECTION VALUE
SLOPE CORRECTION VALUE
OUTPUT %LOAD
X[%] θo*y(1+L)+Xo(1-K)
X0%
MAX%
MIN%
θo
K=0
L=0
X[%]
y
X[%]
20
MAX/MIN DETECTION UNIT

FIG. 4



E/L STATE
(S)
30
IDLE DETECTION UNIT
MIN%
40
FIRST COMPARATOR
(ENL)
CENL
50
ERROR CORRECTING PROCESSING UNIT
K
SLOPE OPERATION UNIT
60
θ₀
θ₁
SECOND COMPARATOR
70
(Eθ)
(CEθ)
SLOPE CORRECTING PROCESSING UNIT
80
L

FIG.5

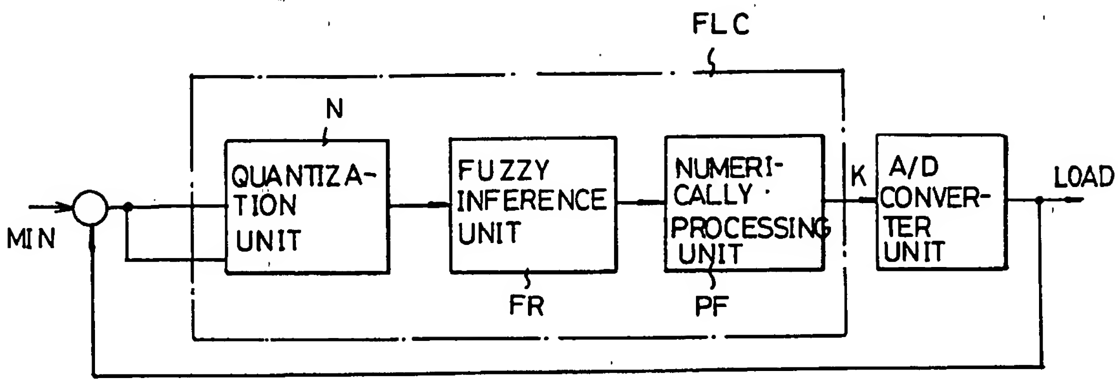

FLC
N
QUANTIZA-TION UNIT
FUZZY INFERENCE UNIT
NUMERI-CALLY PROCESSING UNIT
K
A/D CONVER-TER UNIT
LOAD
MIN
FR
PF

FIG.6

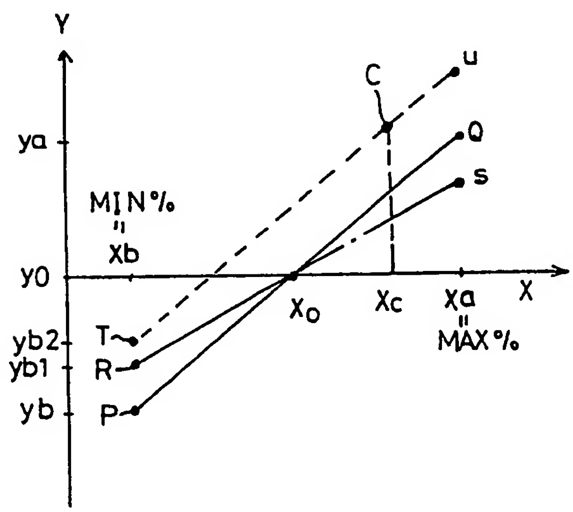

Y
ya
y0
yb2
yb1
yb
MIN%
Xb
T
R
P
C
u
Q
s
Xo
Xc
Xa
MAX%
X

FIG. 7A

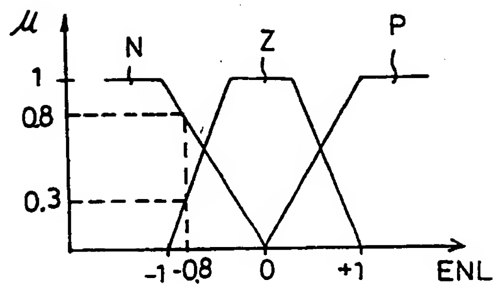


FIG. 7B

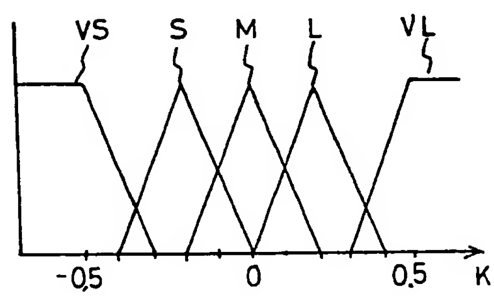


FIG. 8

CENL=ENL(t)-ENL(t-1)

CENL \ ENL	N	Z	P
N	VL	L	VL
Z	L	M	S
P	VS	S	VS

FIG. 9

RULE FOR K IDLE CORRECTION VALUE

RL1 if ENL=N and CENL=N
THEN K=VL

RL2 if ENL=N and CENL=Z
THEN K=L

⋮

RL9 if ENL=P and CENL=P
THEN K=VS

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WEIGHT DETECTING APPARATUS FOR ELEVATOR

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an apparatus for detecting the total weight of passengers ridden in an elevator, and more particularly to a weight detecting apparatus for an elevator using an anti-vibration rubber as a passenger's weight sensor so as to accurately detect the passenger's weight from a displacement of the anti-vibration rubber.

Description of the Prior Art

In terms of control performance of elevators, it is very important to accurately detect the total weight of passengers ridden in an elevator car. In other words, a good ride feeling can be ensured only when an elevator is controlled by an appropriate starting torque corresponding to the passenger's weight. The weight of passengers is utilized as data for controlling an operation of an elevator such as an estimate of no vacancy and a calculation of the number of riding/alighting passengers at every stair.

As weight detecting methods for elevators, there have been proposed various methods such as a method of converting

a displacement of an anti-vibration rubber variable depending on the weight of passengers into a voltage, a method of counting the number of passengers by use of a photoelectric device attached to an elevator door, a method of detecting the weight of passengers by an analysis of image data scanned by a camera installed in the interior of a car, and a method detecting the weight of passengers by use of a matrix attached with a weight sensor such as a piezoelectric element and installed on the car bottom. Among these methods, the method of converting a displacement of an anti-vibration rubber into a voltage has been widely used in terms of an economy.

Referring to FIG. 1, there is illustrated a conventional weight detecting apparatus for an elevator utilizing a displacement of an anti-vibration rubber. As shown in FIG. 1, the apparatus comprises an anti-vibration rubber installed beneath an elevator car 1, a differential transformer 3 for converting the displacement of the anti-vibration rubber 2 into an electrical signal, an A/D converter unit 5 for converting the output signal from the differential transformer 3 into a digital signal indicative of load detection data, an input unit 6 for processing the load detection data in the form of weight data, a storage unit 7 for storing the weight data received from the input unit 6, an output unit 8 for processing the weight data stored in the storage unit 7 and thereby outputting a torqu ignal for a drive motor or a

control signal for data about the number of riding/alighting passengers, and a microprocessor 9 for outputting control signals respectively for driving the input unit 6, the storage unit 7 and the output unit 8.

In FIG. 1, the reference character AB denotes an address line, the reference character DB denotes a data bus, and the reference numeral 4 denotes a resistor.

Operation of the conventional elevator weight detecting apparatus will now be described in conjunction with FIGS. 1 and 2.

When a passenger rides in the car 1, the anti-vibration rubber 2 is retracted in proportion to the passenger's weight. At this time, the differential transformer 3 is downwardly moved by the displacement of the anti-vibration rubber 2. Due to this movement of the differential transformer 3, a variation occurs in magnetic flux interlinking with the primary coil and the secondary coil. As a result, a voltage proportional to the displacement of the anti-vibration rubber is induced at the secondary coil.

The voltage is applied to the A/D converter unit 5 via the voltage adjusting resistor 4 and then converted into a digital signal by the A/D converter unit 5 which, in turn, load detection data. Where no passenger is present in the car 1, the load detection data of the A/D converter unit 5 corresponds to 0%. When the total w ight of passeng rs in the

car 1 corresponds to the rated load of the elevator, the load detection data of the A/D converter unit 5 corresponds to 100%.

The load detection data from the A/D converter unit 5 is fed via the input unit 6 to the microprocessor 9 which, in turn, outputs a control signal. By this control signal, the load detection data is transferred to a correspondingly-designated address of the storage unit 7.

In other words, the total weight of passengers currently ridden in the car 1 can be detected from the load detection data stored in the designated address.

For instance, load detection data outputted from the A/D converter unit 5 and expressed by a hexadecimal digit of $(32)_{16}$ corresponds to a decimal digit of $(50)_{10}$ indicative of 50%. Where the elevator has the rate load of 1,600Kg, this load detection data is indicative of the total weight of passengers currently ridden in the car 1 being 800Kg.

As mentioned above, the total weight of passengers is converted into a mechanical displacement and then an electrical signal respectively by the anti-vibration rubber and the differential transformer in the conventional apparatus. In this conventional apparatus, however, it is impossible to accurately detect the total weight of passengers because the electrical signal obtained by the conversion may not corre pond to the actual weight due to a variation in

elastic coefficient of the anti-vibration rubber generating the mechanical displacement, a variation in voltage at the primary coil of the differential transformer and variations in other characteristics of the differential transformer. Furthermore, the conventional apparatus requires a check and an adjustment periodically. As a result, a degradation in performance may occur.

The above-mentioned problems encountered in the conventional apparatus can be understood by referring to FIG. 2 which is a characteristic curve illustrating an error in load detection data caused by variations in characteristics of the differential transformer of FIG. 1. The characteristic curve is depicted on the orthogonal coordinates having an X-axis indicative of load detection data and a Y-axis indicative of output voltages from the coils of the differential transformer 3. In the orthogonal coordinates, an initial value setting is performed such that the value of 100% is the load detection data Xa on X-axis corresponding to the point Q at which the output voltage Ya on Y-axis of the secondary coil of the differential transformer 3 meets with the characteristic curve PQ of the differential transformer 3 whereas the value of 0% is the load detection data Xa on X-axis corresponding to the point P at which the output voltage Yb on Y-axis of the primary coil of the differential transformer 3 meets with the characteristic curve PQ of the

differential transformer 3.

Initially, the characteristic curve PQ has the form of a line indicative of the initially adjusted characteristic of the differential transformer 3. This linear characteristic curve PQ may be deformed to a curve TU due to the above-mentioned variation factors, as shown in FIG. 2. In this case, the load detection data indicative of the total weight of passengers is erroneously detected. For example, the load detection data of X% indicated by the characteristic curve PQ is detected as XA% by the deformed characteristic curve TU. As a result, an error ENL corresponding to a value of XB% - XA% occurs in the load detection data.

SUMMARY OF THE INVENTION

Therefore, an object of the invention is to provide a weight detecting apparatus for an elevator capable of always detecting correct weight of passengers without any requirement of periodical check and adjustment by comparing the minimum value of load detection data detected from an elevator state signal with the minimum value of initially set load detection data, detecting a variation in a characteristic curve of a differential transformer on the basis of the comparison, and then automatically executing a correction of an error in load detection data generated du to the variation of th

characteristic curve and a correction of a variation in the error.

In accordance with the present invention, this object can be accomplished by providing a weight detecting apparatus for an elevator, comprising: a load detection data unit for operating load detection data by a ratio of a weight of passengers ridden in a car of said elevator to a rated load of said elevator and outputting said load detection data; a maximum/minimum value detection unit for recording a maximum value and a minimum value of said load detection data; an idle detection unit for detecting an elevator state signal indicative of an idle state of said elevator and outputting load detection data indicative of said idle state, a first comparator for comparing said load detection data outputted from said idle detection unit with said minimum value stored in said maximum/minimum value detection unit and outputting an error in load detection data generated at said idle state and a variation in said error; an error correcting processing unit for determining a first correction value for correcting said error and said error variation from an output signal of said first comparator, correcting a characteristic curve of a differential transformer by said first correction value, and applying said first correction value to said load detection data unit so as to enable an outputting of ldad detection data by said corrected characteristic curve; a slope operating unit

for operating a slope from said load detection data outputted from said load detection unit; a second comparator for comparing said slope outputted from said slope operating unit with a slope recorded in said load detection data unit and outputting an error in slope of said characteristic curve of said differential transformer and a variation in said slope error; and a slope correcting processing unit for determining a second correction value for correcting said slope error and said slope error variation outputted from said second comparator, correcting said characteristic curve of said differential transformer by said second correction value, and applying said second correction value to said load detection data unit so as to enable an outputting of load detection data by said corrected characteristic curve.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and aspects of the invention will become apparent from the following description of embodiments with reference to the accompanying drawings in which:

FIG. 1 is a view of a conventional weight detecting apparatus for an elevator;

FIG. 2 is a characteristic curve illustrating an error in load detection data caused by variations in characteristics of the differential transformer of FIG. 1;

FIGS. 3 and 4 are block diagrams of an elevator detecting apparatus for an elevator in accordance with the present invention, respectively;

FIG. 5 is a block diagram of an error correcting processing unit of FIG. 4;

FIG. 6 is a characteristic curve of a differential transformer employed in accordance with the present invention;

FIG. 7A is a diagram illustrating functions P, Z and N to which the an error and an error variation belong;

FIG. 7B is a diagram illustrating a correction value K of load detecting data and fuzzy sets VL, L, M, S, and VS; and

FIGS. 8 and 9 are diagrams respectively illustrating the procedure of inferring the correction value K in a fuzzy inference unit of a fuzzy control unit of FIG. 6.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 3 to 5, there is illustrated an A/D converter unit of a weight detecting apparatus for an elevator in accordance with the present invention. This weight detecting apparatus includes the same construction as that of the conventional apparatus shown in FIG. 1, except for the construction of the A/D converter unit. For the simplicity of description, only the construction of the A/D converter unit will be d scrib d while a detailed description with reference

to other units will be omitted.

As shown in FIGS. 4, the A/D converter unit 5 comprises a load detection data unit 10 for operating a passenger's weight detection signal y outputted from the differential transformer 3 (FIG. 1) in the form of a percentage weight of a rated load of the elevator and outputting the resultant load detection data X%, a maximum/minimum value detection unit 20 for recording the maximum value MAX% and the minimum value MIN% of the load detection data X%, an idle detection unit 30 for detecting an elevator state signal S indicative of an idle state of the elevator and outputting load detection data X% indicative of the idle state, a first comparator 40 for comparing the load detection data X% outputted from the idle detection unit 30 with the minimum value MIN% stored in the maximum/minimum value detection unit 20 and outputting an error ENL in load detection data generated at the idle state of the elevator and a variation CENL in the error, an error correcting processing unit 50 for determining a correction value K for correcting the error ENL and the error variation CENL from an output signal of the first comparator 40, a slope operating unit 60 for operating a slope θ_1 from the load detection data X% outputted from the load detection unit 30, a second comparator 70 for comparing the slope θ_1 outputted from the slope operating unit 60 with a slope θ_0 recorded in the load detection data unit 10 and outputting an error ENL in

a slope of a characteristic curve of the differential transformer 3 (FIG. 1) and a variation CENL in the error, and slope correcting processing unit 80 for determining a correction value L for correcting the error ENL and the error variation CENL outputted from the second comparator 70.

As shown in FIG. 5, the error correcting processing unit 50 comprises a fuzzy control unit FLC for controlling a fuzzy ambiguity of human being's logic. The fuzzy control unit FLC includes a quantization unit Qn for quantizing the error ENL of the load detection data and the error variation CENL, a fuzzy inference unit FR for classifying an output signal of the quantization unit Qn by a function to which the output signal belongs, so as to express the output signal by a fuzzy set, and inferring the classified output signal by rules RL1 to RL9, and a numerically-processing unit DF for numerically processing an inference determined by the fuzzy inference unit FR and thereby outputting a correction value K.

The slope correcting processing unit 80 comprises a fuzzy control unit having the same construction as that of the error correcting processing unit 40.

Operation of the weight detecting apparatus in accordance with the present invention will now be described, in conjunction with FIGS. 3 to 9.

When a passenger's weight detection signal y from the differential transformer 3 is applied to th load det ction

data unit 10 of the A/D converter unit 5 after an initial installation of an elevator, the load detection data unit 10 outputs load detection data X1% by operating the following equation:

$$X1\% = \theta_0 * Y + Y_0$$

In the equation, θ_0 stands for the slope of the characteristic curve PQ of the differential transformer 3. The slope θ_0 can be derived from the following equation:

$$\theta_0 = \tan^{-1}(Xa - Xb)/(Ya - Yb)$$

The characteristic curve PQ is one having been subjected to an adjustment. Where the weight of passengers in the car 1 is the rated load of the elevator, the adjustment is achieved such that the output voltage Y from the differential transformer 3 corresponds to Ya. In this case, the initial value is set by the maximum value MAX% corresponding to 100% of the load detection data Xa. On the other hand, the adjustment at the idle state is achieved such that the output voltage Y from the differential transformer 3 corresponds to Yb. In this case, the initial value is set by the minimum value MIN% corresponding to 0% of the load detection data Xa.

For respective passenger's weights corr sponding to the

rated load, the idle load, and the 1/2 load, load detection data X% are set by Xa (Xa = MAX%), Xb (Xb = MIN%) and X_0 which are values on X-axis of the characteristic curve PQ of the differential transformer 3, respectively, as shown in FIG. 6.

The load detection data X1 is applied to the maximum/minimum value detection unit 20 so as to output the maximum value MAX% and the minimum value MIN% of the load detection data. The maximum value MAX% and the minimum value MIN% are stored.

On the other hand, when a passenger's weight detection signal y from the differential transformer 3 is applied to the load detection data unit 10 of the A/D converter unit 5 during an operation of the elevator, the load detection data unit 10 outputs load detection data X2 by operating the following equation:

$$X2\% = \theta_0 * Y(1 + L) + X_0(1 - K)$$

In the equation, θ_0 stands for the slope of the characteristic curve PQ of the differential transformer 3. The slope θ_0 can be derived from the equation: $\theta_0 = \tan^{-1}(Xa - Xb)/(Ya - Yb)$. The correction values K and L can be calculated in the error correcting processing unit 50 and the slope correcting processing unit 80, respectively. When load detection data is detected by the initially set characteristic

curve PQ, both the correction values K and L are zero.

The load detection data X2 is applied to the maximum/minimum value detection unit 20 so as to output the maximum value MAX% and the minimum value MIN% of the load detection data. The maximum value MAX% and the minimum value MIN% are stored again.

When the output voltage of the differential transformer 3 at the idle state is changed from the value Yb to the value Yb_2 due to a variation in characteristic, as shown by the characteristic curve TB of FIG. 6, an error ENL in load detection data and a variation CENL of the error are generated. In this case, the load detection data error, its error variation, an error in the slope of the deformed characteristic curve and its error variation are corrected by the correction values K and L respectively outputted from the error correcting processing unit 50 and the slope correcting processing unit 80.

A method of monitoring the load detecting data outputted from the A/D converter 5 according to the state of the elevator may be considered to be used. In this case, however, an erroneous detection of load detection data may occur when the characteristic of a load detection device itself is varied. To this end, the method of detecting the idle state from the elevator state signal S is used in accordance with the present invention.

The elevator state signal S is outputted from the elevator when the elevator is not moved for a predetermined time of, for example, not less than 30 seconds while being maintained with door closed at a normal operation state other than a maintenance or a failure. This elevator state signal S is applied to the idle detection unit 30 which, in turn, outputs load detection data indicative of the idle state. In the first comparator 40, this load detection data is compared with the minimum value MIN% initially set and stored in the maximum/minimum value detection unit 20. By the comparison, an error ENL indicative of the difference between the load detection data and the minimum value MIN% and its error variation CENL are derived. The derived error ENL and its error variation CENL are then applied to the error correcting processing unit 50.

The correction of the error ENL and the error variation CENL is executed by the fuzzy control unit FLC which controls a fuzzy ambiguity of human being's logic.

That is, the error ENL and the error variation CENL are deformed into a fuzzy set by the quantization unit QN. The error ENL and the error variation CENL expressed by the fuzzy set are then classified by functions P, Z and N to which the error ENL and the error variation CENL belong.

The output signal outputted from the quantization unit Qn is received in the fuzzy inference unit FR and then inf rred

by a defined rule RL. In accordance with the used rule RL, when both the error ENL and the error variation CENL are negative (N), a fuzzy set VL for providing a very large correction value K is selected, as shown in FIGS. 8 and 9. In similar, other rules, namely, a fuzzy set VL (very large), a fuzzy set L (large), a fuzzy set M (medium), a fuzzy set S (small) and a fuzzy set VS (very small) may be inferred, based on the used rule RL, when both the error ENL and the error variation CENL. The inferred fuzzy set is applied to the numerically-processing unit DF which, in turn, outputs a correction value K.

For example, when both the error ENL and the error variation CENL are -0.8, five rules RL1 to RL5 corresponding to the fuzzy sets N and Z for the error ENL and the fuzzy sets N and Z for the error variation CENL are used so as to output the correction value K.

On the other hand, the characteristic curve of the differential transformer 3 is deformed to a characteristic curve RS of FIG. 6, it can be found that both the load detection data at the idle state and the slope of the characteristic curve are varied. The slope error Eθ and the error variation CEθ are corrected by a correction value L determined in the same manner as in the above-mentioned correction procedure of the error ENL and the error variation CENL achieved using the correction value K.

The correction values K and L are applied to the load detection data unit 10 again. In the load detection data unit 10, load detection data X2 is detected using the following equation:

$$X2\% = \theta_0 * Y(1 + L) + X_0(1 - K)$$

As mentioned above, the load detection data operated by the characteristic curve of the differential transformer corrected by the correction values K and L is stored in the load detection data unit 10 again. The corrected characteristic curve is used for detection of load detection data. Accordingly, it is possible to always accurately detect the weight of passengers ridden in the car, even if an error in passenger's weight detection may occur due to a variation in the initially set characteristic curve of the differential transformer 3.

As apparent from the above description, the present invention provides a weight detecting apparatus for an elevator capable of correcting an error in passenger's weight occurring due to variations in characteristics of an anti-vibration rubber and a differential transformer, thereby achieving a correct weight detection.

Although the preferred embodiments of the invention have been disclosed for illustrative purposes, those skilled in the

art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

CLAIMS

1. A weight detecting apparatus for an elevator, comprising:

a load detecting data unit for operating load detection data by a radio of a weight of passengers riding in a car of the elevator to a rated load of the elevator and outputting the load detection data;

a maximum/minimum value detection unit for recording a maximum value and a minimum value of the load detection data;

an idle detection unit for detecting an elevator state signal indicative of an idle state of the elevator and outputting load detection data indicative of the idle state,

a first comparator for comparing the load detection data outputted from the idle detection unit with the minimum value stored in the maximum/minimum value detection unit and outputting an error in load detection data generated at said idle state and a variation in the error;

an error correcting processing unit for determining a first correction value for correcting the error and the error variation from an output signal of the first comparator, correcting a characteristic curve of a differential transformer by the first correction value, and applying the first correction value to the load detection data unit so as to enable an outputting of load detection data by the corrected characteristic curve;

a slope operating unit for operating a slope from the load detection data outputted from the load detection unit;

a second comparator for comparing the slope outputted from the slop operating unit with a slope recorded in the load detection data unit and outputting an error in slope of the characteristic curve of said differential transformer and a variation in the slope error; and

a slope correcting processing unit for determining a second correction value for correcting the slope error and the slope error variation outputted from the second comparator, correcting the characteristic curve of the differential transformer by the second correction value, and applying the second correction value to the load detection data unit so as to enable an outputting of load detection data by the corrected characteristic curve.

2. A weight detecting apparatus in accordance with claim 1, wherein said error correcting processing unit comprises a fuzzy control unit for controlling a fuzzy ambiguity of human being's logic, the fuzzy control unit serving to determined the first correction value.

3. A weight detecting apparatus in accordance with claim 1, wherein the slope correcting processing unit comprises a fuzzy control unit for controlling a fuzzy ambiguity of human being's logic, the fuzzy control unit serving to determined said second correction value.

4. A weight detecting apparatus substantially as described herein with reference to th accompanying Figures 3-9.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report)	Application number GB 9400037.9
Relevant Technical Fields (i) UK Cl (Ed.M) G1N (NACF, NAHA) (ii) Int Cl (Ed.5) G01G 23/01, 23/16	Search Examiner M G CLARKE Date of completion of Search 7 MARCH 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATBASES: WPI	Documents considered relevant following a search in respect of Claims :- 1 TO 4

Categories of documents

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P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
A	EP 0124355 A2 (K K ISHIDA KOKI) whole document	
A	US 4674605 (ASS TO OTIS ELEVATOR CO) whole document	
A	US 4667153 (J H DOYLE) whole document	
A	US 4137979 (ASS TO KUBOTA LTD) whole document	

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